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#18 Appeal Brief Inzirillo 3/5/02

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re application of:	
Michael E. Fein	Examiner: G. Inzirillo
Application No.: 08/988,479	Art Unit: 2881
Filed: December 10, 1997	APPELLANT'S BRIEF UNDER 37 CFR §1.192
For: NON-IMAGING OPTICAL CORNER TURNER	

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

The following is Appellant's Appeal Brief submitted in triplicate pursuant to 37 C.F.R. §1.192. A petition for a five-month extension of time is submitted concurrently herewith in a separate paper.

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REAL PARTY IN INTEREST

Nellcor Puritan Bennett of 4280 Hacienda Drive, Pleasanton, California is the real party in interest as the assignee of the above-identified application.

RELATED APPEALS AND INTERFERENCES

No other appeals of interferences are known which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

STATUS OF CLAIMS

Claims 2-31 and 48-54 are pending in this application. The claims are presented in the attached appendix.

I. Appellant appeals the rejection of the of pending claims 2-31 and 48-54 as allegedly being indefinite for failing to particularly point out and distinctly claim the subject matter which the Appellant regards as the invention.

II. Moreover, Appellant appeals the rejection of claims 2-11, 25-31, 51 and 54 under 35 U.S.C. § 102(b) as allegedly being anticipated by U.S. Patent No. 4,489,450 to Jannson et al. ("Jannson").

STATUS OF AMENDMENTS

No amendments subsequent to the final rejection have been filed.

SUMMARY OF THE INVENTION

The present claimed invention relates to a suite of devices that <u>efficiently</u> change the direction of a beam of light in a <u>non-imaging</u> application. The invention utilizes non-imaging optical constructions whose purpose is the efficient transfer of optical power from one place to another, with minimal loss in the concentration of that power, and with no need for retaining image qualities. These non-imaging devices are particularly useful in changing the direction of light that is carried by optical fibers, although they may also be useful in any optical system requiring the redirection of a light beam. Embodiments of the present invention provide devices to efficiently turn light from an optical fiber around a corner while avoiding the loss that would occur if the fiber were bent.

Embodiments of the present invention include corner turners that have curved reflective surfaces. The curved reflective surfaces may be made from segments that could be circular, elliptical or hybrid segments made from combining parabolic segments with elliptical ones. Additionally, the present claimed invention, by recognizing that most light from a fiber optic source will have divergence half-angles less than 90 degrees, achieves a practical solution using non-imaging corner turners in conjunction with non-imaging optical concentrators. Accordingly, in alternate embodiments, the present invention combines corner turners with non-imaging optical concentrators that could be tuned to receive light from optical fibers having divergence half-angles less than 90 degrees. The combined corner tuner and concentrator embodiments provide a compact device for efficiently changing the direction of light that is carried by optical fibers.

ISSUES

There are two issues being presented for review, these are:

I. Whether the rejection of the pending claims 2-31 and 48-54 under 35 U.S.C. § 112, second paragraph, as allegedly being indefinite for failing to particularly point out and distinctly claim the subject matter which the Appellant regards as the invention, was proper.

II. Whether the rejection of claims 2-11, 25-31, 51 and 54 under 35 U.S.C. § 102(b) as allegedly being anticipated by U.S. Patent No. 4,489,450 to Jannson et al. ("Jannson") was proper.

GROUPING OF THE CLAIMS

For the purposes of this appeal, the pending claims are grouped as follows:

Group I: Claims 2-11, 51 and 54 are in Group I.

Group II: Claims 12-16, 52 and 53 are in Group II.

Group III: Claims 17-24 are in Group III.

Group IV: Claims 25-31 are in Group IV.

Group V: Claims 48-50 are in Group V.

ARGUMENT

I. Rejections Under 35 U.S.C. § 112, Second Paragraph Were Improper

The final rejection of all pending claims under 35 U.S.C. § 112, second paragraph is one basis for the present appeal. Appellant contends that the claims properly and particularly point out and distinctly claim the subject matter which the Appellant regards as the invention.

According to the MPEP section 2173.02, "in reviewing a claim for compliance with 35 U.S.C. 112, second paragraph, the Examiner must consider the claim as a whole to determine whether the claim apprises one of ordinary skill in the art of its scope and, therefore, serves the notice function required by 35 U.S.C. 112, second paragraph. Furthermore, section 2173.02 also states that: "definiteness of claim language must be analyzed, not in a vacuum, but in light of:

(A) The content of the particular application disclosure;

(B) The teachings of the prior art; and

(C) The claim interpretation that would be given by one possessing the ordinary level of skill in the pertinent art at the time the invention was made."

Appellant contends that the pending claims are definite under 35 U.S.C. 112, second paragraph, literally as they stand and when analyzed in light of: the content of the particular application disclosure; and the claim interpretation that would be given by one possessing the ordinary level of skill in the pertinent art at the time the invention was made.

The Examiner's rejections under 35 U.S.C. § 112, second paragraph were directed towards several terms and phrases, each of which is addressed below.

(i) Description of the term "Non-Imaging Optical Concentrator"

One basis for the rejections of claims 2-31 and 48-54 for being indefinite as stated by the Examiner is that the "non-imaging optical concentrator can be misunderstood to be a separate item of the optical setup when it is in fact a physical part of the non-imaging optical waveguide."

The phrase "non-imaging optical concentrator" is recited in independent claims 2, and 12. In these claims the non-imaging optical concentrator is recited as a separate item coupling an optical fiber to a first port of a corner-turner. As it is recited in these claims, the

non-imaging optical concentrator is indeed a separate item. This notion that the concentrator is a separate item is supported for example, in the specification describing different embodiments of the present invention, where some embodiments use a non-imaging optical concentrator and some don't. For example, Fig. 3 and its supporting description beginning on page 25, line 10 of the specification, describe a corner turner setup that does not use a non-imaging optical concentrator and Fig. 4 and its supporting description beginning on page 27, line 1 of the specification, describe a corner turner that uses a non-imaging concentrator.

As described in the specification, the non-imaging optical concentrator may be a compound parabolic concentrator (CPC) or any other optical concentrator known in the art. The waveguide of the present invention may require the use of a concentrator when the waveguide is configured to work with light received from a fiber optic bundle that has a divergence half-angle of less than 90 degrees. The waveguide of the present invention may not require a concentrator when the divergence half-angle of the light being received by the waveguide is 90 degrees. For example, in claims 2 and 12 where the light is received from a bundle having a divergence angle of less than 90 degrees, a concentrator is recited, and where a concentrator is not a necessary element, as in other claims such as claim 4, it is not recited.

In addition, the specification on page 14, lines 29-30, sets forth that: "the corner turner output may be as far as desired from the CPC exit." This recitation and other similar ones clearly establish that the non-imaging optical concentrator is a separate item that can be made to be an integral part with the corner turner. For example, the specification on page 14 lines 12-15 recites that the "input portion of the reflector is a compound parabolic concentrator." As another example, the specification on page 16 lines 31-35 describes "the input CPC" portion. These descriptions establish that the concentrator is a separate piece.

The reason that the present claimed invention optionally uses a non-imaging optical concentrator is to remove a bending angle limit that may exist with these corner turners. A form of this limit is described on page 14, lines 3-6 of the specification. As described in the specification, in any system where the divergence angle is low, the maximum bending angle of a light beam in a corner turner may be limited. For these systems where the bend angle is limited, two solutions are taught. One solution is to accept the divergence-angle-imposed limitation on the maximum bending angle and hence make up the desired turn by combining allowable

maximum turns. For example, Fig. 3, and its corresponding description beginning on page 25, line 10 of the specification describe an embodiment of a corner turner setup that does not use a non-imaging optical concentrator.

Another solution for addressing the maximum bending angle limitation is to address the source of the limitation which is the divergence angle itself. This other solution, is one that involves an increase in the divergence angle by passing the light through a concentrator to increase the divergence angle of the beam of light which is incoming to the bending device. For example, Fig. 4 and its corresponding description beginning on page 27, line 1 of the specification describe an embodiment of a corner turner that uses a non-imaging concentrator.

Additionally, the discussion on page 29 lines 4-6 of the specification states that "several embodiments have employed CPC's to transform beams of low NA to beams whose NA is 1.0." Lastly, the specification on page 29, lines 9-14 provides that: "corner turner systems using such CPCs, or other optical concentrators may be advantageous in producing more easily fabricated corner turner structures, e.g. structures which do not require elliptical surfaces on the inner sides of the surfaces or structures which achieve a desired turning of the light beam in one turn i.e., 90 degree turn in a single swept bend.

Therefore, Appellant maintains that the use of the phrase "non-imaging optical concentrator" will not be misunderstood. The concentrator is a separate item of the optical setup. It may in fact be a physical part of the non-imaging waveguide, but as described above, it does not necessarily have to be. Accordingly, Appellant contends that the rejection directed to the term "non-imaging optical concentrator" is improper and should be overturned.

(ii) Description of the word "Port"

Another basis for the Examiner's rejections of claims 2-31 and 48-54 for being indefinite is that the "description of the word ports are misleading and incorrect." The Examiner states that "ports as described, where present in the claims, can be mistaken for a connection device coupling the non-imaging optical waveguide to the optical fiber, when they are in fact the openings in the non-imaging waveguide that allow the light to pass through." Appellant suspects that the Examiner's rejection is perhaps based on the notion that a port in a non-imaging optical waveguide which is an opening in the non-imaging optical waveguide cannot also serve as a

connection device coupling the non-imaging optical waveguide to other optical devices such as the optical fiber or a non-imaging optical concentrator.

The term "port" is the most commonly used term by those having ordinary skill in the art of designing optical coupling devices. As used by those having ordinary skill in the art, the term port is used to define both an opening and a coupling location. Appellant respectfully submits that the term "port" is more definite than the term "opening." While the term "port" is a definite term describing a physical aspect of a device, the term "opening" is a less definite term, since an "opening" is merely a reference to a void.

The word "port" as described and recited in the claims is meant to be both an opening that allows light to pass through and an <u>opening that is adapted to be coupled</u> to an optical fiber - i.e., a connection device. As recited in nearly every claim, the term port is used to define an opening which is "**<u>connected</u>**" to the waveguide so as to act as a port for light rays to pass through the apparatus (e.g. as recited in claims 2, 4, 8, 12, 17, 25, 26, 27, 28 and 48) and the term port is also used to define a connection device when terms such as "**<u>connected</u>**" or "**<u>adapted to be coupled</u>**" are used in conjunction with the word "port."

For example, the specification on page 13 lines 30-35 reads: "a rectangular input surface would connect to the fiber optic..." As can be inferred from this sentence, a port is an opening (input surface) through which light passes, and in this case, input surface 32 is the port. The specification further provides that input surface 32 would connect to the fiber optic, hence clearly setting forth that the port besides being an opening, can be adapted to serve as a connection device.

The word port as used by the Appellant and as recited in the claims is meant to convey the two non-exclusive definitions of the term, namely that ports are not only openings in the non-imaging waveguide that allow light to pass through, but they are also elements of the claimed invention that are capable of acting as connection devices connecting the waveguide to other optical devices. Therefore, the rejection to the use of the word "port" is improper and should be overturned.

(iii) Description of Sections Parallel to the Plane of said Corner is Unclear

Another basis for the rejections of claims 2-31 and 48-54 for being indefinite is that the "description of the sections parallel to the plane of said corner is unclear, where present in the claims, since neither the sections nor the plane are defined..." The phrase "sections parallel to the plane of said corner" appears in independent claims 8, 17 and 24 and in dependent claims 6, 13, 15, 16, 18, and 19.

Appellant respectfully contends that as is generally known to all and especially to those of skill in the art of non-imaging optical devices, nearly all three-dimensional objects have a dominant plane and every geometric shape can have sections. The rejection is focused by the Examiner's statement that neither the sections nor the plane are defined. In response, Appellant respectfully submits that sections and planes are inherently present in every geometric shape, and those possessing ordinary skill in the relevant art are quite fluent in recognizing planes and sections in optical devices. The plane of the corner (or bend) as is understood by all who are skilled in the art, is used to mean the plane through which the maximum angle of the bend is exposed. More specifically, the description on page 13, lines 26-35 of the specification in describing the geometry of Fig. 1D clearly defines both the plane of the bend and sections parallel to that plane. The claim limitations directed to "the sections parallel to the plane of the corner " are definite in a literal sense, as they stand in the claims; they are definite as interpreted in light of the content of the particular application disclosure; and they are definite as interpreted by one possessing the ordinary level of skill in the pertinent art at the time the invention was made."

Lastly, the Examiner in stating his 102 rejections, discussed below, uses language describing the Fig. 11 in the cited art in terms of "<u>sections parallel to the plane of the bend</u>." Appellant argues that the phrase "section parallel to the plane of said corner" as used in the specification and present in the claims relies on the same inherent definition used by those of ordinary skill in the optical arts and which has also been used by the Examiner. The Examiner's use of the terms, "<u>sections parallel to the plane of the bend,</u>" supports the fact that the Appellant's use of the term "plane of the bend" is definite and consistent with how the term is clearly understood by those of ordinary skill in the optical arts. Accordingly, Appellant

maintains that the description of "sections parallel to the plane of said corner" where present in the claims is not unclear and contends that the rejection directed to this phrase is improper and should be overturned.

(iv) Manner in Which They Are Identical is not Mentioned (i.e., sections are identical)

Another one of the rejections under 35 U.S.C. 112 is based on the Examiner's statement that "the manner in which they are identical is not mentioned...." Appellant submits that this phrase in not indefinite as claimed and is even made more definite when considered in light of the description provided in the specification.

The description in the specification when read in conjunction with Figs. 1 and 2 establishes that in "2d" corner turners, sections parallel to the plane of the corner are <u>geometrically</u> identical. Therefore, embodiments that claim a "2d" corner turner recite the fact that sections parallel to the plane of the bend are identical as, for example, recited in dependent claims 15 and 18.

However, "3d" corner turners, for example, as shown in Fig. 5 and as described beginning on page 27, line 23 of the specification, will not have sections parallel to the plane of the corner that are identical. Accordingly, when a claim is directed towards a non-2d corner turner, there are no recitations that limit the sections parallel to the plane of the corner to be identical. Therefore, Appellant maintains that all section parallel to the plane of the corner are geometrically identical for the 2d corner turner cases and are not identical for the 3d corner turner cases. Accordingly, Appellant maintains that the recitation directed toward the manner in which the sections are identical is definite and contends that the rejection directed to this phrase is improper and should be overturned.

(v) Upper and Lower Surfaces of the Waveguide are not Defined

The Examiner also rejects the claims under 35 U.S.C. 112, second paragraph, as being indefinite because the "upper and lower surfaces of the waveguide are not defined." The terms "upper" and "lower" surfaces of waveguides are recited in independent claims 8, 15, 18 and 48. As used in these claims the upper and lower surfaces of the waveguide are described as

planar reflective surfaces. Appellant respectfully submits that as is generally known to those having ordinary skill in the optics art, a waveguide typically has a surface bounding it and that any three-dimensional shape - such as a waveguide- inherently has an upper and a lower surface. This inherent definition related to the upper and lower surfaces of the waveguide and also they being planar reflective surfaces is defined in the specification on page 13, lines 30-31 in describing the geometry of Fig. 1D. The terms "upper" and "lower" especially when read in light of the description provided in the specifications are definite; the rejection is improper and should be overturned.

(vi) Unclear How There Can Be Planar Reflective Surfaces in Two Sections of a Parabola and How a Corner is Formed in the Parabolic Sections

The Examiner has also rejected all pending claims under 35 U.S.C. 112, second paragraph, because according to the Examiner "it is unclear how there can be planar reflective surfaces in two sections of a parabola, and similarly how a corner (generally understood to contain a right angle) is formed in the parabolic sections." Appellant argues that the above phrases, when read in light of the description provided in the specification, are definite and clear. In addressing this rejection, first the question of how a corner is formed from parabolic sections is addressed, and then the issue of how the planar reflective surfaces are connected to parabolic sections is explained.

1. <u>Corner Formed from Parabolic Sections</u>

The specification on page 18, line 10 through page 20, line 20 and page 20, lines 21 through page 24, line 16 describes the construction steps for an embodiment of the optical corner turner of the present invention that has parabolic sections. Fig. 2 and the corresponding description show that the outer curved reflective section of the optical corner turner is formed by the joining of two parabolas, each starting from an end of the corner turner, by an ellipse. This description shows how a corner turner is made from parabolic sections. While the Appellant fully appreciates that a corner is generally understood to contain a right angle, the present claimed invention sets forth a waveguide that is adapted to direct light around a corner, and one

way of directing light around a corner is by gradually bending the light around a corner by combining parabolic sections.

2. Planar Reflective Surfaces

Having described above, how a corner is formed using parabolic sections, Appellant will now show that the specification clearly explains how planar reflective surfaces coexist with the two parabola sections. As described in the specification on page 5, lines 11-17, an aid to the visualization of such a 2d corner turner is a curved 90 degree bend in a rectangular-cross-section air conditioning duct. Such a bend is made from four surfaces: (1) an inside of the turn curved surface, (2) an outside the turn curved surface, (3) an upper flat (planar) surface, and (4) a lower planar surface. The flat upper and lower surfaces meet the curved surfaces at their respective edges.

Turning now to the corner turners in the claimed invention, the description provided in the specification shows first of all, that planar reflective sections are not constructed from parabolas, but that curved reflective sections are. As explained above, the planar reflective surfaces exist in "2d" corner turners. The planar reflective surfaces are a pair of flat (planar) surfaces that are the upper and lower surfaces of the waveguide. It then follows that, the curved surface made from the parabolic sections is the outside of turn surface as shown in Figs 1I, 1J or 2. The inside of turn surface as shown in Figs 1I and 1J is also a flat surface, although it does not have to be. The two inside of turn and outside of turn reflective segments meet the planar reflective surfaces at their respective edges and make up the four surfaces that bound the waveguide.

In light of theses descriptions provided in the specification, Appellant maintains that the claims literally, as they stand, and when read in light of the specification are clear and definite. Appellant argues that the rejection directed to the indefiniteness of the "planar reflective surfaces and parabolic sections" is improper and should be overturned.

In conclusion, for reasons set forth above, all the rejections under 35 U.S.C. § 112, second paragraph were improper and should be overturned.

heavily on the language describing the arrangement of Fig. 11 of the Jannson reference. The Jannson patent clearly calls the device of Fig. 11 a <u>four port directional coupler</u> (see col. 7, lines 29-30). The entire disclosure that could be presumed to relate to the corner turning teachings is contained in one sentence where the Jannson patent recites "input beams can be split into output beams by means of a suitable half-mirror..." (see col. 7, lines 31-32). Nowhere else does the Jannson patent provide any teachings related to any device other than a "connector" which is the subject matter of the Jannson patent. Appellant respectfully submits that the use of the phrase "suitable half-mirror" is merely precatory; what is suitable? and how is a half-mirror an optically efficient non-imaging device?

The mere presence of the sentence citing a "a suitable mirror" is a testament to the lack of teachings related to such a device. First, a <u>mirror is an imaging device, and hence not a non-imaging device.</u> Second, a statement directed to a suitable mirror begs the question of "what is a suitable mirror that would work efficiently and in a compact manner?" The Jannson patent does not teach what a suitable mirror is, and/or how one would go about making such a device. Furthermore, a half-mirror besides being an imaging device, is also inherently non-efficient. A half mirror is inefficient because it transmits half and reflects half of the energy that is incident upon it. By reflecting half the incident energy, a half-mirror loses ½ of the incident energy and thus is grossly inefficient. <u>The device shown in Fig. 11 of the Jannson reference, reflects light via an **imaging-type half-mirror** around a corner in an imaging manner, **not in a non-imaging manner.** The Jannson device deflects ½ of its incident light, which is an inefficient redirection of optical energy, **not an efficient** redirection of optical energy.</u>

However, the present invention is entirely focused on teaching a suite of <u>non-imaging</u> devices for the <u>efficient</u> and compact turning of light around a corner from one optical fiber to another. Besides clearly distinguishing the present claimed invention (i.e., an efficient non-imaging optical corner turner) from the cited art (i.e., an optical connector) as set forth above, the Appellant presents two additional arguments for interpreting the teachings of Jannson and further distinguishing the claimed invention from this cited art. These interpretations are that: (1) the cited art device is not optically efficient, and (2) the cited art device uses imaging devices, and hence is not a purely non-imaging device.

Turning to the first argument, Appellant submits that a visual inspection of Fig. 1 of the Jannson reference shows that upon exit from the collimator, light rays may exit with a divergence angle of θ_2. Light rays exiting the collimator at any θ_2 greater than zero have the possibility of missing their target surface, which could be a mirror image of Fig. 1, for example as shown in Fig. 4 (of Jannson). Since light rays could miss the target surface, the arrangement of Fig. 1 (of Jannson) is not optically efficient. <u>Jannson's lack of optical efficiency clearly distinguishes the present claimed invention from the Jannson reference.</u>

Turning now to the second argument, Appellant submits that the Jannson device uses imaging elements to address the potential inherent inefficiencies of its connector. The arrangement for a connector shown in Fig. 2 of Jannson shows a "lens-type front surface" to increase the overall optical efficiency of its system. The lens is used to focus the light rays onto the receiving surface. Here, Jannson is using imaging optical devices such as a lens to increase the efficiency of its in-line beam-to-beam connector. However, the present claimed invention, which is based on non-imaging optics, achieves efficient corner turning without resorting to the use of lens-type imaging devices. <u>The absence of a imaging devices (e.g. a lens) in the present claimed invention further distinguishes it from the Jannson reference.</u>

In conclusion, the Appellant respectfully maintains that the Jannson reference does not anticipate the present claimed invention; the 35 U.S.C. 102(b) rejection was improper and should be overturned.

This Brief is submitted in triplicate.

Respectfully submitted,

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APPENDIX I

Claims for 09/988,479

2. An apparatus for efficiently deflecting light from an optical fiber around a corner, comprising:

a first port adapted to be coupled to said optical fiber and to receive light with divergence angles of less than 90 degrees from the axis of said optical fiber;

a non-imaging optical waveguide, connected to said first port, and adapted to direct light around said corner;

a second port connected to said non-imaging optical waveguide; and

a non-imaging optical concentrator for delivering a beam of light having half-angle divergence of 90 degrees, connected between said optical fiber and said first port.

3. The apparatus of claim 2 further comprising:

a second non-imaging optical concentrator, its high-divergence side connected to said second port.

4. An apparatus for efficiently deflecting light from an optical fiber around a corner, comprising:

a first port adapted to be coupled to said optical fiber and to receive light with divergence angles of less than 90 degrees from the axis of said optical fiber;

a non-imaging optical waveguide, connected to said first port, and adapted to direct light around said corner;

a second port connected to said non-imaging optical waveguide; wherein said second port is adapted to direct light from said optical fiber to a patient, and further comprising:

a third port adapted to be coupled to a second optical fiber and direct light to said second optical fiber with divergence angles of less than 90 degrees from the axis of said second optical fiber;

a second non-imaging optical waveguide, connected to said third port, and adapted to direct light around a corner; and

a fourth port connected to said second non-imaging optical waveguide and configured to receive reflected light from said patient.

5. The apparatus of claim 2 wherein said non-imaging optical waveguide comprises a curved reflective segment connected between said first port and said second port.

6. The apparatus of claim 5 wherein, in any section parallel to the plane of said corner, said curved reflective section appears as an arc of a circle.

7. The apparatus of claim 5 wherein said curved reflective segment is an inner curve, further comprising a second curved reflective segment as an outer curve, which is connected between said first port and said second port.

8. An apparatus for efficiently deflecting light from an optical fiber around a corner, comprising;

a first port adapted to be coupled to said optical fiber and to receive light with divergence angles of less than 90 degrees from the axis of said optical fiber;

a non-imaging optical waveguide, connected to said first port, and adapted to direct light around said corner;

a second port connected to said non-imaging optical waveguide;

wherein every section parallel to the plane of said corner is identical, and upper and lower surfaces of said non-imaging optical waveguide are planar reflective surfaces.

9. The apparatus of claim 6 wherein said arc has a radius of the width of said first port, and a center at an end of said first port at an inside of said turn around said corner.

10. The apparatus of claim 9 wherein said arc extends to said second port at an angle of 60 degrees from a plane of said first port.

11. The apparatus of claim 9 wherein said arc extends to said second port at an angle not exceeding (90°+φ)/2, where φ is the maximum half-angular divergence of rays entering said first port.

12. An apparatus for efficiently deflecting light from an optical fiber around a corner, comprising:

a first port adapted to be coupled to said optical fiber and to receive light with divergence angles of less than 90 degrees from the axis of said optical fiber;

a non-imaging optical waveguide , connected to said first port, and adapted to direct light around said corner;

a second port connected to said non-imaging optical waveguide;

a non-imaging optical concentrator for delivering a beam of light having half-angle divergence of 90 degrees, connected between said optical fiber and said first port; and

wherein said non-imaging optical waveguide comprises a first curved reflective segment extending along an outside of a turn around of said corner, and a second curved reflective segment extending around an inside of said turn around said corner.

13. The apparatus of claim 12 wherein, in any section parallel to the plane of said corner, said first curved reflective segment appears as a section of a first ellipse and said second curved reflective segment appears as a section of a second ellipse.

14. The apparatus of claim 13 wherein
said first ellipse has foci at ends of said second curved reflective segment; and
said second ellipse has foci at ends of said first curved reflective segment.

15. The apparatus of claim 14 wherein:

every section parallel to the plane of said corner is identical, and

upper and lower surfaces of said non-imaging optical waveguide are planar reflective surfaces.

16. The apparatus of claim 14 wherein:

said non-imaging optical concentrator is of the 3D type, and

in every section parallel to the plane of said corner, said first curved reflective segment is of such size as to contact the outer edge of said first port and said second curved reflective surface is of such size as to contact the inner edge of said first port.

17. An apparatus for efficiently deflecting light from an optical fiber around a corner, comprising:

a first port adapted to be coupled to said optical fiber and to receive light with divergence angles of less than 90 degrees from the axis of said optical fiber;

a non-imaging optical waveguide, connected to said first port, and adapted to direct light around said corner;

a second port connected to said non-imaging optical waveguide;

wherein said non-imaging optical waveguide comprises:

a first reflective segment extending along an inside of a turn around said corner from said first port to said second port, such that in any section parallel to the plane of said corner, said first reflective segment appears as a straight line; and

a second reflective segment extending along an outside of said turn around said corner from said first port to said second port, such that in any section parallel to the plane of said corner, said second reflective segment appears as a curve comprising

a first parabolic segment extending from said first port,

an elliptical segment extending from said first parabolic segment, and

a second parabolic segment extending from said elliptical segment to said second port.

18. The apparatus of claim 17 wherein:

every section parallel to the plane of said corner is identical, and

upper and lower surfaces of said non-imaging optical waveguide are planar reflective surfaces.

19. The apparatus of claim 17 wherein:

said first port is circular in cross section, and

in every section parallel to the plane of said corner, said first curved reflective segment is of such size as to contact the outer edge of said first port and said second curved reflective surface is of such size as to contact the inner edge of said first port.

20. The apparatus of claim 17 wherein said elliptical segment is so constructed that the slope of said elliptical segment is equal to slopes of said first and second parabolic segments at their respective points of intersection.

21. The apparatus of claim 17 wherein said elliptical segment has foci at the ends of said first reflective segment.

22. The apparatus of claim 17 wherein said first parabolic segment has a focus at an intersection of said planar reflective segment and said second port.

23. (Unchanged) The apparatus of claim 17 wherein said second parabolic segment has a focus at an intersection of said first reflective segment and said first port.

24. An apparatus for efficiently deflecting light from an optical fiber around a corner, comprising:

a first port adapted to be coupled to said optical fiber and to receive light from the axis of said optical fiber;

a non-imaging optical waveguide, connected to said first port, and adapted to direct light around said corner;

a second port connected to said non-imaging optical waveguide;

wherein said non-imaging optical waveguide comprises:

a first reflective segment extending along an inside of a turn around said corner from said first port to said second port, such that in any section parallel to the plane of said corner, said first reflective segment appears as a straight line; and

a second reflective segment extending along an outside of said turn around said corner from said first port to said second port, such that in any section parallel to the plane of said corner, said second reflective segment appears as a curve comprising

a first parabolic segment extending from said first port,

an elliptical segment extending from said first parabolic segment,

a second parabolic segment extending from said elliptical segment to said second port, wherein said second port is at an angle of less than ninety degrees from said first port, and further comprising:

a third port around a second corner from said second port;

a third reflective segment extending along an inside of a turn around said second corner from said second port to said third port, such that in any section parallel to the plane of said corner, said third reflective segment appears as a straight line;

a fourth reflective segment extending along an outside of said turn around said second corner from said second port to said third port, such that in any section parallel to the plane of said corner, said fourth reflective segment appears as a curve comprising:

a third parabolic segment extending from said second port,

a second elliptical segment extending from said third parabolic segment, and

a fourth parabolic segment extending from said second elliptical segment to said third port.

25. An apparatus for efficiently deflecting light from an optical fiber around a corner, comprising:

a first port adapted to be coupled to said optical fiber and to receive light with divergence angles of less than 90 degrees from the axis of said optical fiber;

a non-imaging optical waveguide, connected to said first port, and adapted to direct light around said corner;

a second port connected to said non-imaging optical waveguide;

wherein said first and second ports are rectangular.

26. An apparatus for efficiently deflecting light from an optical fiber around a corner, comprising:

a first port adapted to be coupled to said optical fiber and to receive light with divergence angles of less than 90 degrees from the axis of said optical fiber;

a non-imaging optical waveguide, connected to said first port, and adapted to direct light around said corner;

a second port connected to said non-imaging optical waveguide; and

wherein said first and second ports are circular.

27. An apparatus comprising:

a first optical fiber;

a first port coupled to said first optical fiber;

a first non-imaging optical waveguide, connected to said first port, and adapted to receive light with divergence angles up to the maximum angle which can propagate with low loss in said first fiber optic around a 90 degree corner;

a second port connected to said non-imaging optical waveguide to direct light to a patient;

a second optical fiber;

a third port coupled to said second optical fiber;

a second non-imaging optical waveguide, connected to said third port, and adapted to direct light around said 90 degree corner to said second optical fiber with divergence angles up to the maximum that can propagate with low loss in said second optical fiber; and

a fourth port connected to said second non-imaging optical waveguide and configured to receive reflected light from said patient.

28. An optical beam delivery system comprising at least one optical fiber and a non-imaging corner turner comprising:

a first port adapted to be coupled to said optical fiber and to receive light with divergence angles of less than 90 degrees from the axis of said optical fiber;

a non-imaging optical waveguide, connected to said first port, and adapted to direct light around said corner; and

a second port connected to said non-imaging optical waveguide.

29. An optical beam delivery system comprising at least one optical fiber and a non-imaging corner turner according to claim 27.

30. An optical beam delivery system according to claim 28, in which said non-imaging corner turner is integrally molded upon an end of said optical fiber.

31. An optical beam delivery system according to claim 29, in which said non-imaging corner turner is integrally molded upon an end of said optical fiber.

48. An apparatus for directing around a corner a beam of light, said beam having divergence half-angle of 90 degrees or less, while conserving étendue, comprising:

a first port adapted to receive said beam of light,

a non-imaging light guide, connected to said port, and adapted by means of a bend to direct said beam of light around said corner,

a second port connected to said non-imaging light guide,

wherein said non-imaging light guide comprises a first curved reflective segment extending along an outside of a turn around said corner, and

a second curved reflective segment extending around an inside of said turn around said corner,

wherein in any section parallel to a plane drawn through the bend, said first curved reflective segment appears as a first elliptical section and said second curved reflective segment appears as a second elliptical section.

49. The apparatus of claim 48 wherein every section of said apparatus parallel to the plane of the bend is identical and wherein said non-imaging light guide further comprises an upper surface and a lower surface wherein said upper surface and said lower surface are planar reflective surfaces.

50. The apparatus of claim 48, wherein in every section parallel to the plane of the bend, said first curved reflective segment is of such size as to contact said first port at

an outer edge and said second curved reflective surface is of such size as to contact said first port at an inner edge.

51. The apparatus of claim 2 wherein said non-imaging optical concentrator is a compound parabolic concentrator.

52. The apparatus of claim 12 wherein said non-imaging optical concentrator is a compound parabolic concentrator.

53. The apparatus of claim 16 wherein said non-imaging optical concentrator is a compound parabolic concentrator.

54. The apparatus of claim 3 wherein said second non-imaging optical concentrator is a compound parabolic concentrator.